Airborne Measurements of $H_2O(v)$, CO, CH_4, and N_2O

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Measurement Description: Tracer gas measurements will be provided using two techniques: an external path, near-IR diode laser hygrometer for $H_2O(v)$ (DLH); and a folded-path, differential absorption mid-IR diode laser spectrometer for CO, CH_4, and N_2O (DACOM). Instrumentation types slated for the DC-8 aircraft as well as their performance characteristics are listed in Table 1 followed by brief instrument descriptions.

Table 1.

Instrument	Species	Time Response	Precision (1σ)	Accuracy
DLH	$H_2O(v)$	50 msec	1% or 0.1 ppmv	10% or 1 ppmv
DACOM	CO	1 sec	1% or 1 ppbv	2%
DACOM	CH_4	1 sec	0.1%	1%
DACOM	N_2O	1 sec	0.1%	1%

Diode Laser Hygrometer (DLH): The DLH has been successfully flown during several previous field campaigns including TOTE, VOTE, SUCCESS, SONEX, PEM-Tropics A and B, SOLVE, AFWEX and TRACE-P. This sensor measures water vapor ($H_2O(v)$) via absorption of a strong, isolated line in the (101) combination band near 1.4 μm and is comprised of a compact laser transceiver mounted to a DC-8 window plate and a sheet of high grade retroflecting road sign material applied to an outboard DC-8 engine housing to complete the optical path. Using differential absorption detection techniques, $H_2O(v)$ is sensed along the 28.5m external path negating any potential wall or inlet effects inherent in extractive sampling techniques. A laser power normalization scheme enables the sensor to accurately measure water vapor even when flying through clouds. An algorithm calculates $H_2O(v)$ concentration based on the differential absorption signal magnitude, ambient pressure, and temperature, and spectroscopic parameters that are measured in the laboratory.

Diode Laser In-Situ (DACOM): The spectrometer system, referred to as DACOM (Differential Absorption CO Measurement), includes three tunable diode lasers providing 4.7, 4.5, and 7.6μm radiation for accessing CO, N_2O, and CH_4 absorption lines respectively. The three laser beams are combined by the use of dichroic filters and are then directed through a small volume (0.3 liter) Herriott cell enclosing a 36 meter optical path. As the three coincident laser beams exit the absorption cell, they are spectrally isolated using dichroic filters and are then directed to two InSb detectors and one MCT detector, one for each laser wavelength. A wavelength reference cell containing several torr each of CO, CH_4, and N_2O is used to wavelength lock the operation of the three lasers to the appropriate absorption lines. Ambient air is continuously drawn through a Rosemont inlet probe and a permeable membrane dryer which removes $H_2O(v)$ before entering the Herriott cell and subsequently being exhausted via a vacuum pump to the aircraft cabin. To minimize potential spectral overlap from other atmospheric species, the Herriott cell is maintained at a reduced pressure of 100 Torr. At 5 SLPM mass flow rate, the absorption cell volume is exchanged twice every second assuming piston flow. Frequent but short calibrations with well documented and stable reference gases are critical to achieving both high precision and accuracy. Calibration for all species is accomplished by periodically (~ every 12 minutes) flowing calibration gas through this instrument. By interpolating between these calibrations, slow drifts in instrument response are effectively suppressed yielding the high precision values shown in Table 1. Measurement accuracy is closely tied to the accuracy of the reference gases obtained from NOAA/CMDL, Boulder, CO.